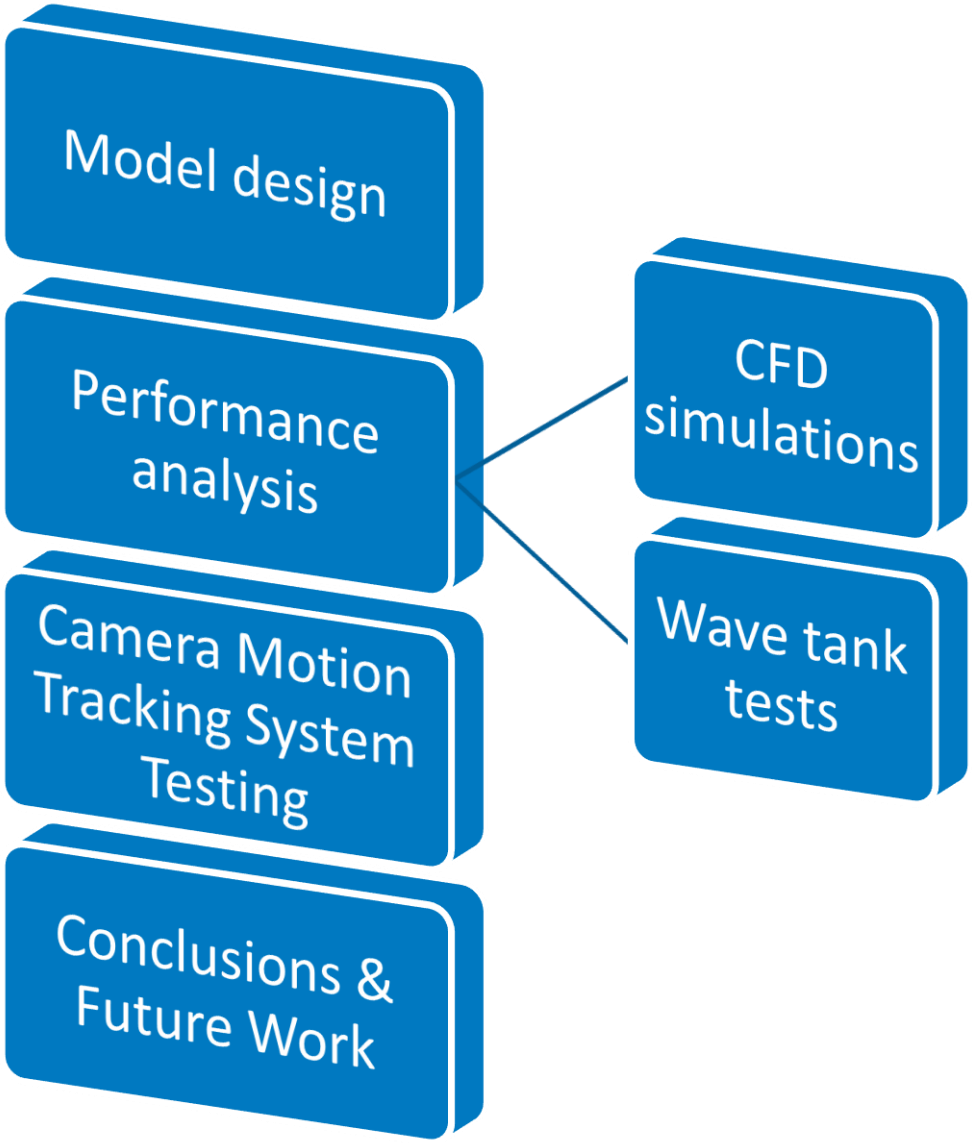
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

MEDA Model 3 Review – Floating-point absorber wave energy system

Ye Li – NREL
Yi-Hsiang Yu – NREL
Robert Thresher – NREL
Michael Lawson – NREL
Eric Nelson– NREL

MEDA Model Meeting
August 23-24, 2011

Presentation Outline



Objective

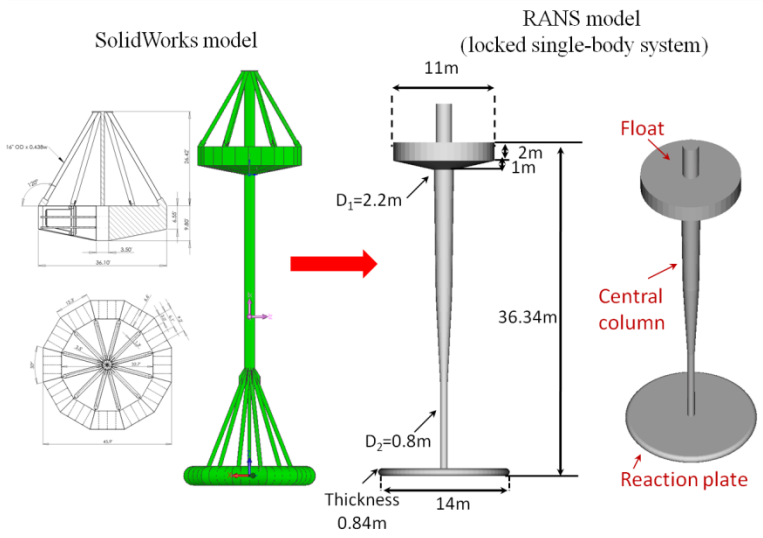
To investigate the performance of a practical floating point absorber (FPA) wave energy system

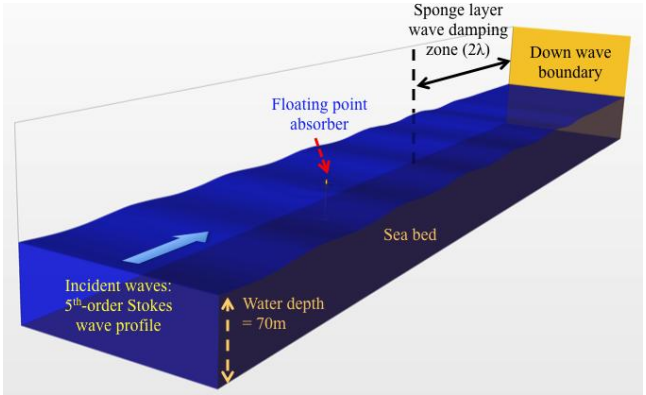
- The hydrodynamic effects of the system, including the nonlinear interaction between waves and the FPA system

- Power absorption efficiency in operational wave conditions

FPA modeling

Model geometry





Single-body simulation

- 3 DOF
- Including the mooring system
- Extreme wave conditions

CFD simulations

Wave tank test at UC Berkeley

Two-body simulation

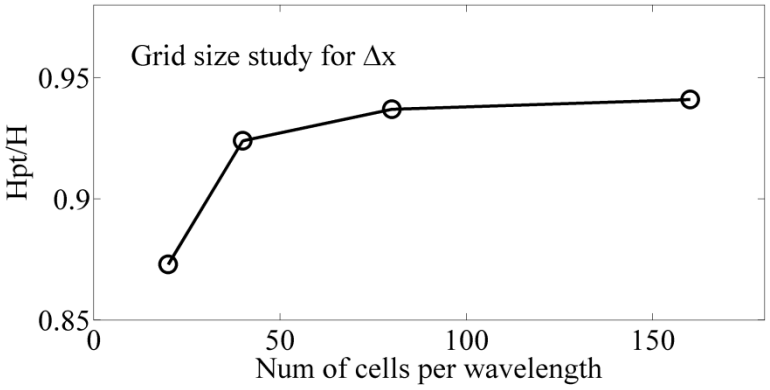
- Heave only (no mooring)
- Including power take off
- Operational wave conditions

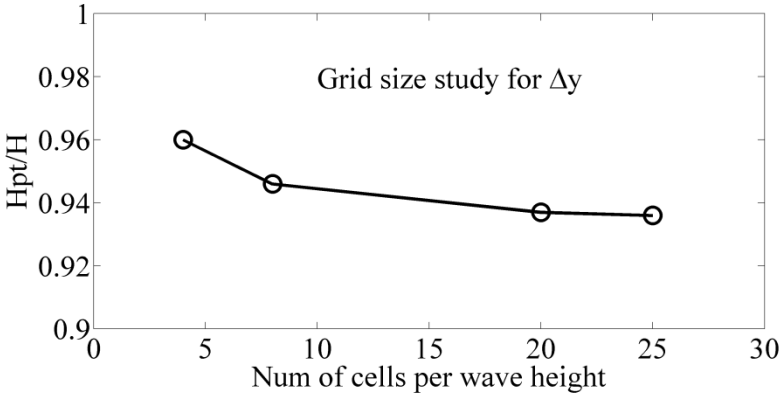
CFD simulations

Wave tank test at UCSD

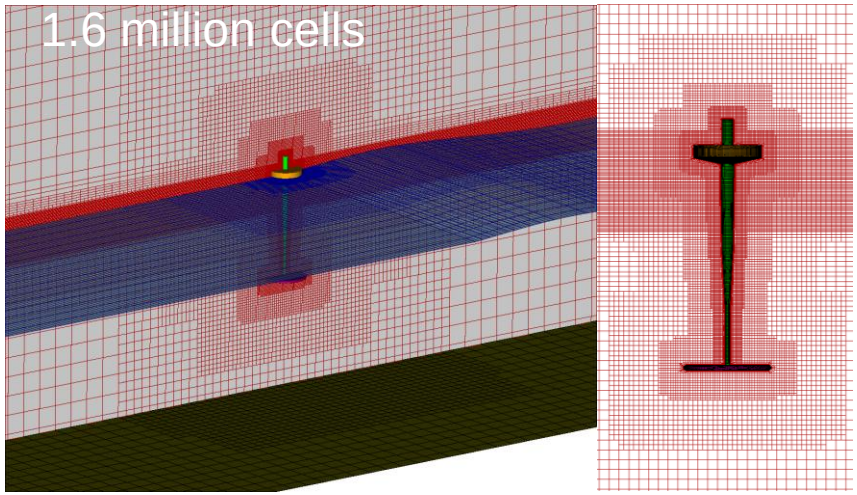
Grid Study for the RANS simulation

Grid study for capturing the wave dynamics





Study of grid resolution around the FPA model



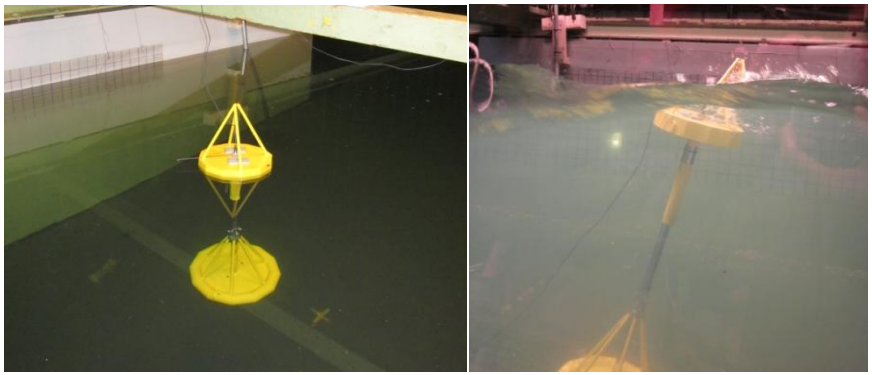
Results

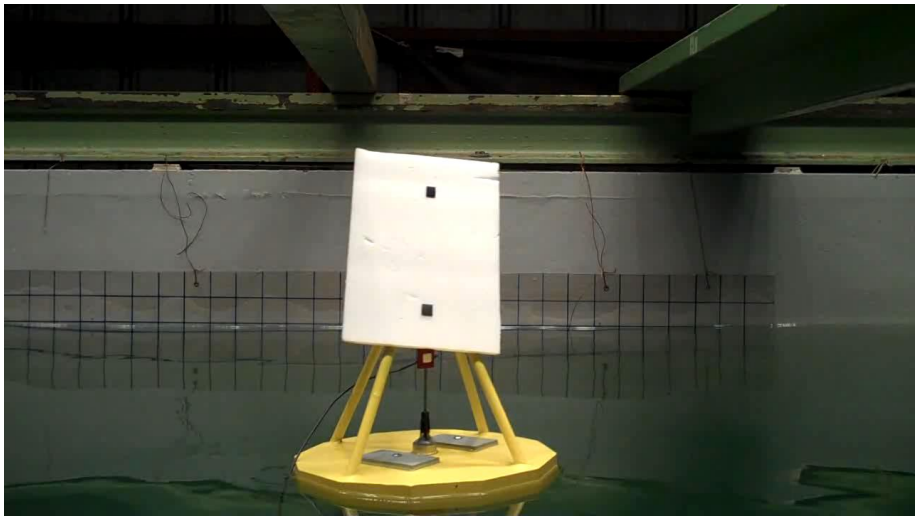
- Hydrodynamic response of the FPA system in waves
  - ❖ Locked single body FPA model
  - ❖ Two-body FPA model

- Power absorption efficiency (two-body FPA model)

Single-Body FPA in waves

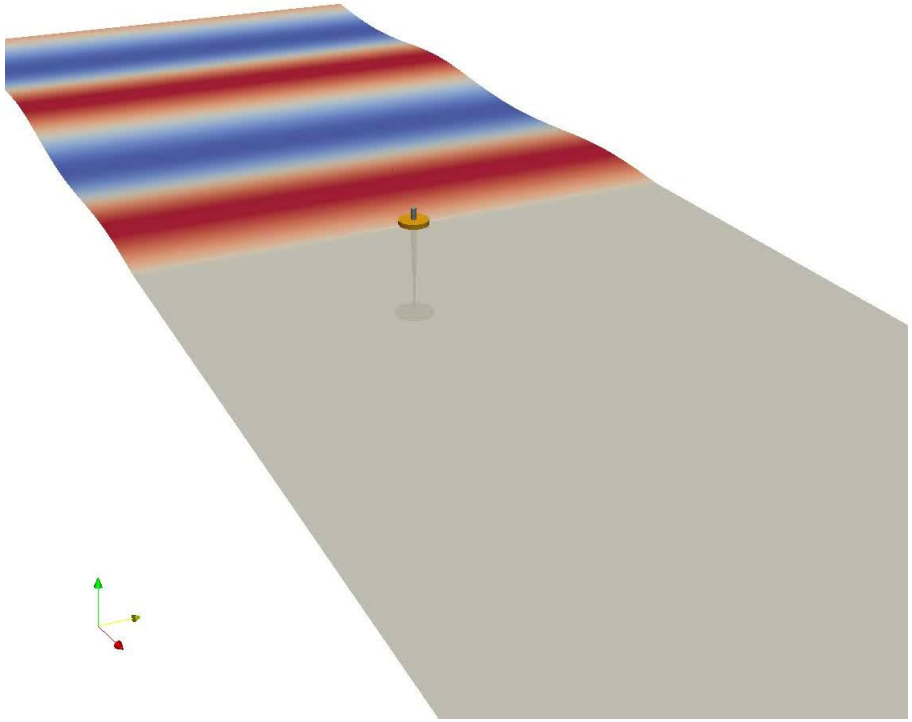
UC Berkeley wave tank test (H=2m to H=20m in full scale)





Wave height H=6 m & wave period T=10sec (full scale)

RANS simulation

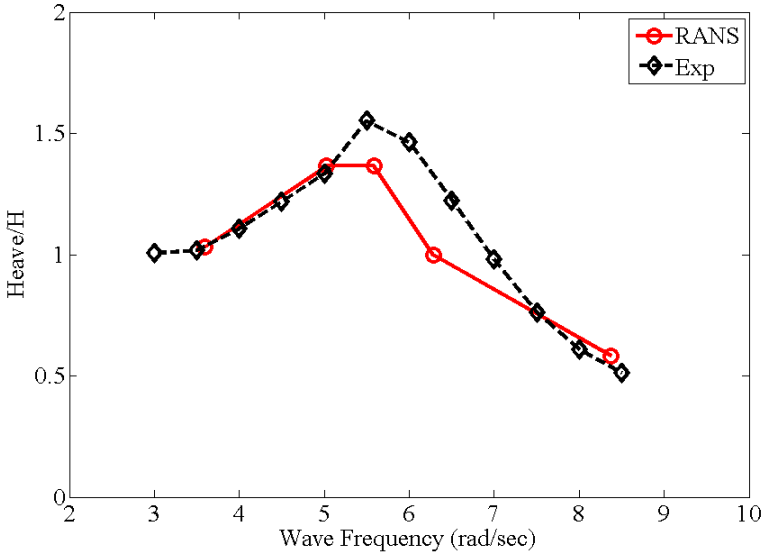


5th-order Stokes waves
(wave height H=4 m; wave period T=10sec)

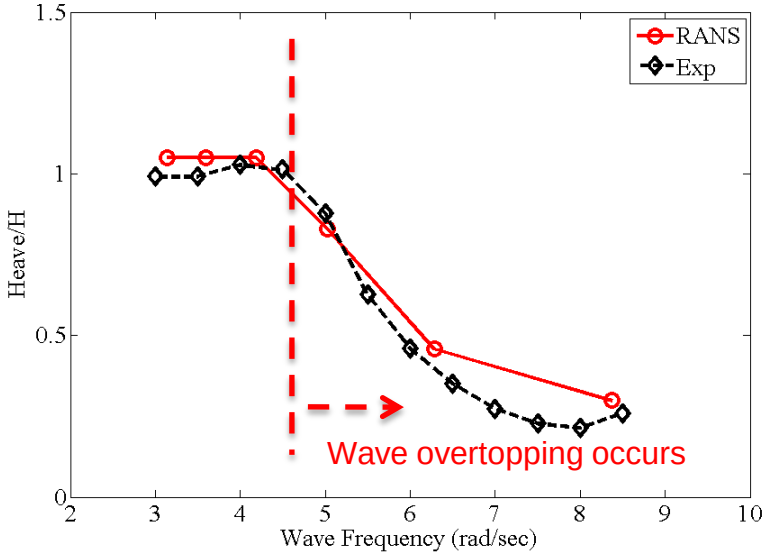
Single-Body FPA in waves

- 1/100 model scale
- Li & Yu & Mirko (IWWWFB 2011)

H=0.03m (3m in full scale)

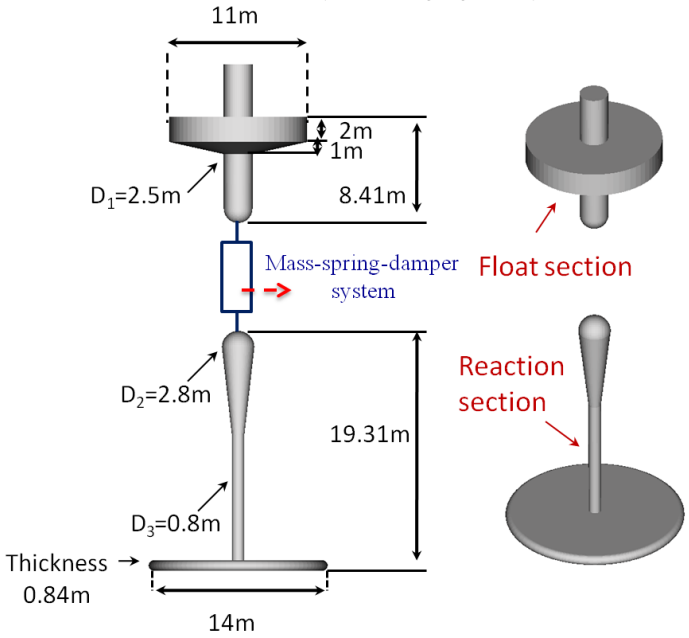


H=0.1m (10 in full scale)

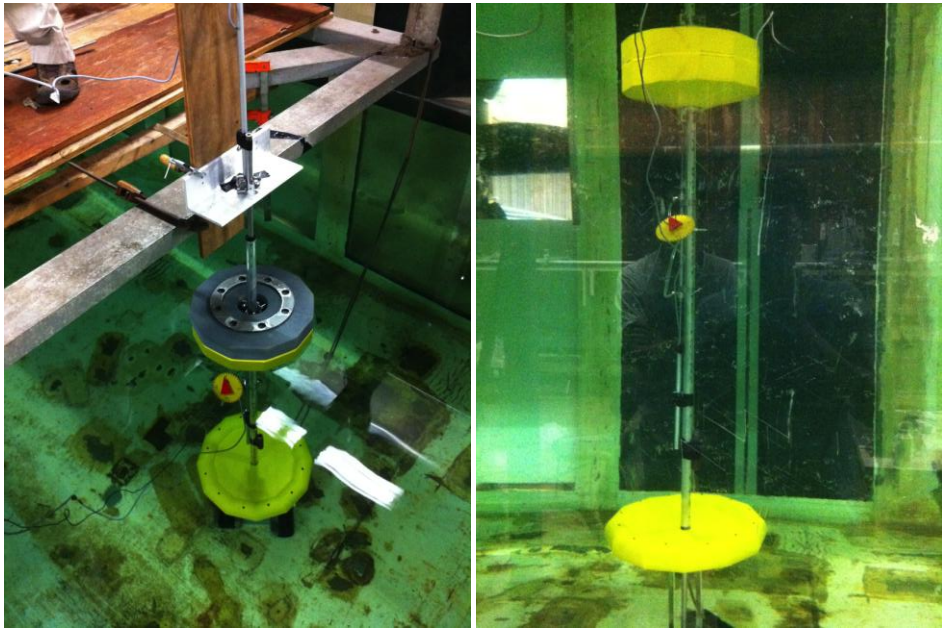


Two-Body FPA Modeling (Heave Only)

RANS simulation model

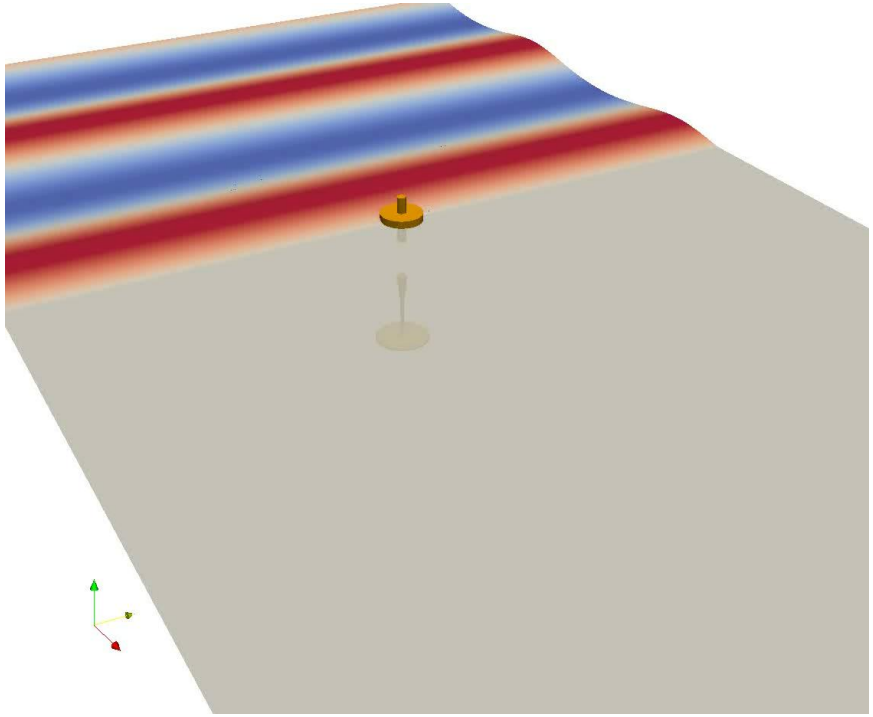


Wave tank test

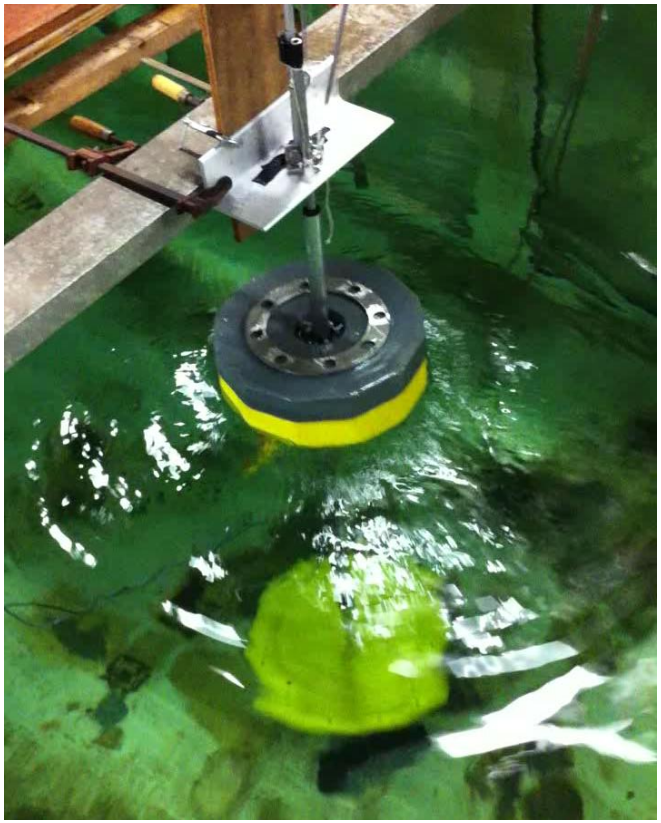


Two-Body FPA Modeling (Heave Only)

CFD simulation
(wave height H=4 m; wave period=7sec)

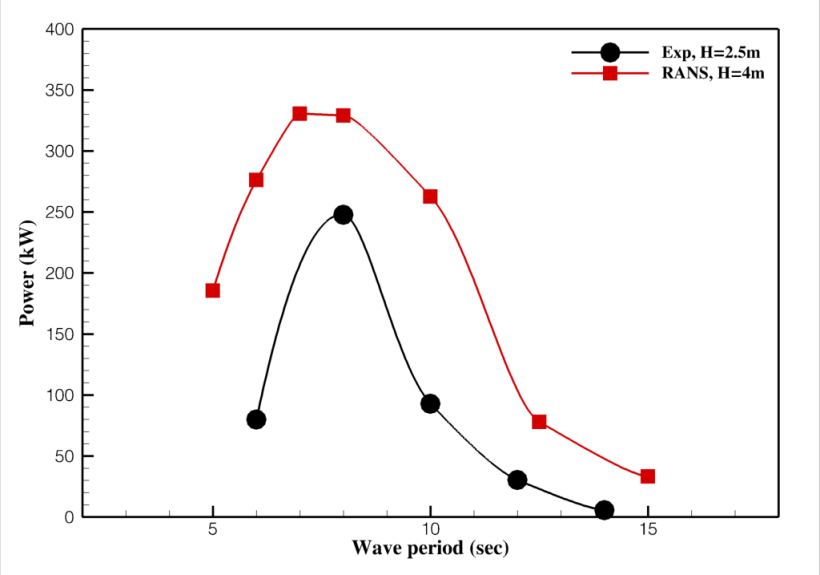


Wave tank test (wave height H=2.5 m; wave period=8sec in full scale)

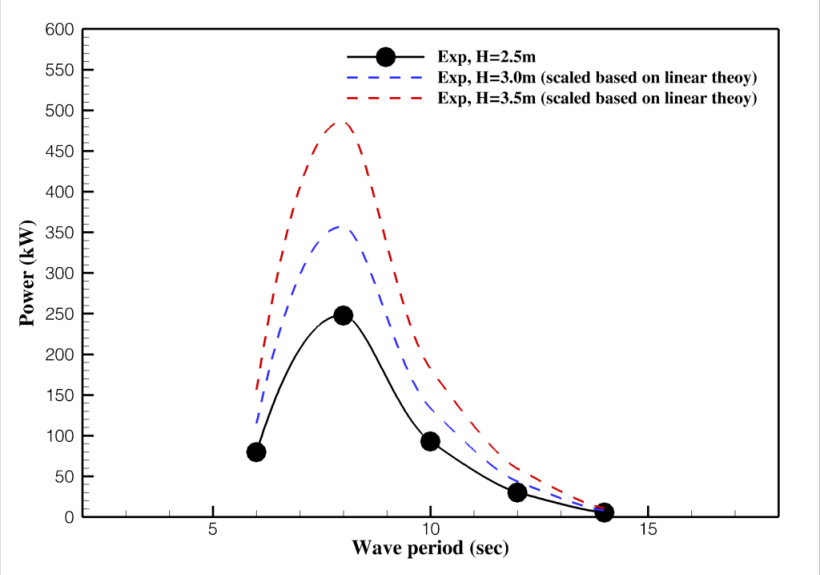


Power Conversion

Power generation prediction from CFD simulation (H=4m) and experimental wave tank test (2.5m)



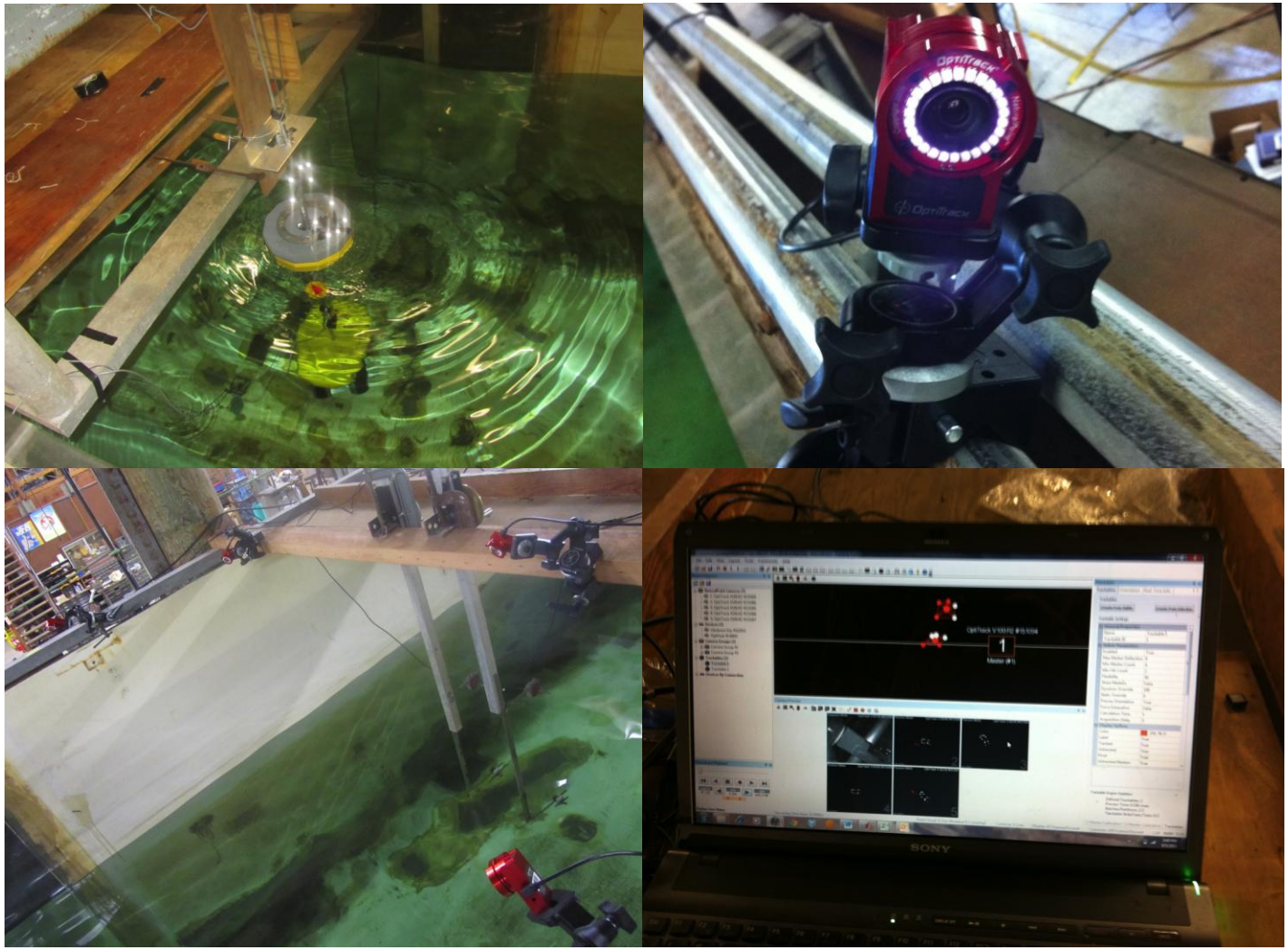
Estimated power generation from experimental test data



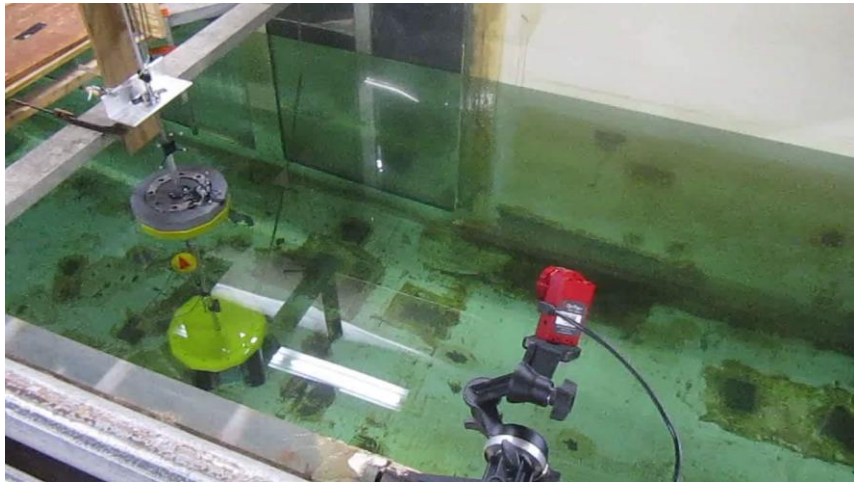
- Float geometry was modified during the experimental wave tank test (further CFD simulation is needed).
- Nonlinear interaction effects (wave overtopping & viscous damping) on power generation?

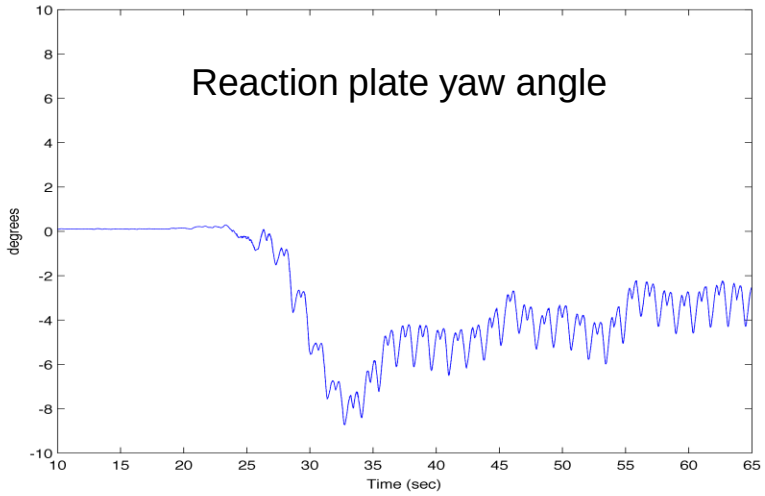
Camera Motion Tracking System Testing

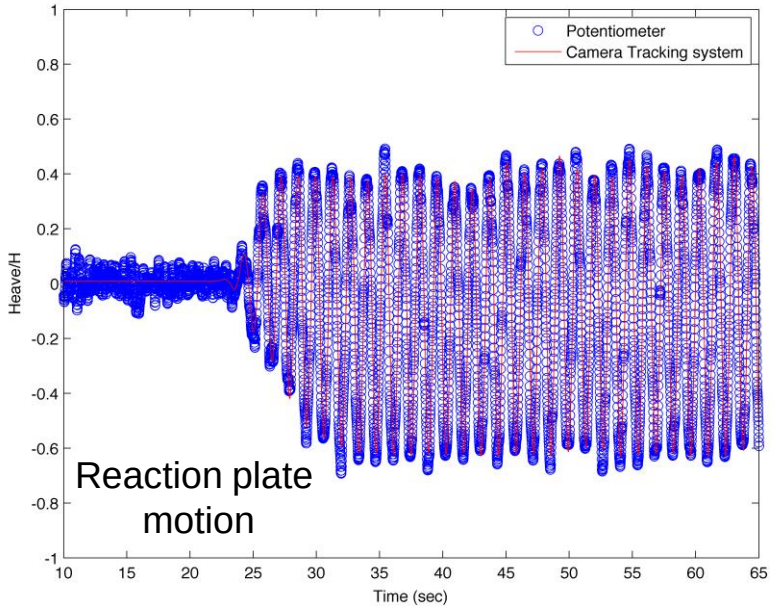
Camera System Settings

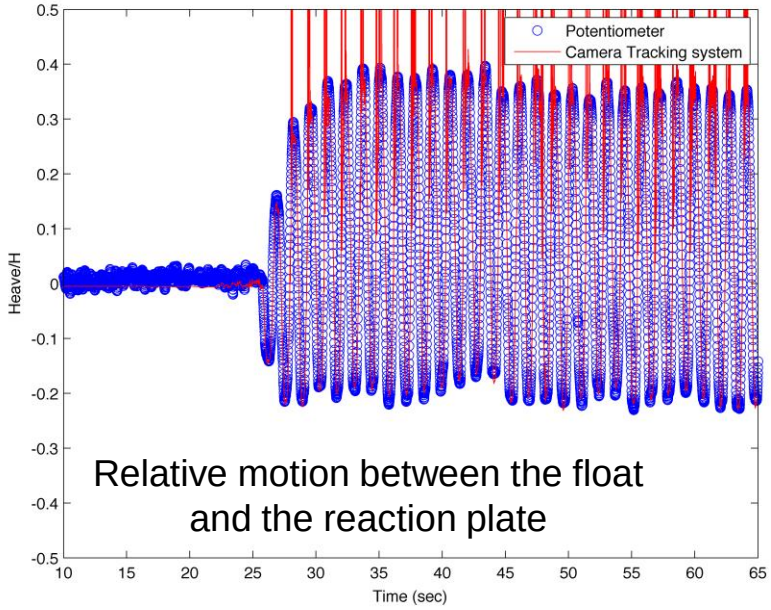


Motion Tracking









76mm; T=1.39sec (H=2.5m; T=8sec in full scale); damping coefficien≈1200 kNs/m (full scale)

Conclusions and Future Work

- The study demonstrated a work of modeling (both CFD simulations and experiments) the FPA system in waves.
  - More CFD simulations will be conducted for validation
  - More experimental tests and CFD simulations will be conducted for a more efficient device (larger float).
  - **It is very important to conduct the experimental test in parallel with model development.**
- The new camera motion tracking system has been tested and it works very well.
- Cost effective mooring system design, buoy geometry (size) optimization and the application of control strategies will be in the future work as well.